What is claimed is:

1. An apparatus for reducing noise in a block-based decoded image signal including a luminance component, said apparatus comprising:

an image region classifier responsive to said luminance component for analyzing each luminance pixel value of the luminance component according to a corresponding luminance pixel spatial context in a same frame of said image signal to classify the luminance pixel to a selected one of a plurality of predetermined image region classes associated with distinct image region spatial characteristics and to generate a corresponding selected region class indicative signal;

a shape-adaptive luminance noise power estimator responsive to said luminance component and said selected region class indicative signal for estimating statistical characteristics of said luminance pixel by using local window segmentation data associated with the luminance pixel, to generate a corresponding luminance noise power statistical characteristics indicative signal; and

a shape-adaptive luminance noise reducer for filtering said luminance component according to said luminance noise power statistical characteristics indicative signal.

2. The apparatus according to claim 1, wherein said distinct image region spatial characteristics includes edge, near edge, flat, near flat and texture spatial characteristics.

3. The apparatus as claimed in claim 2, wherein said image region classifier comprises:

a high frequency noise component reducer for receiving at least said luminance pixel value and providing a filtered luminance pixel value;

a plurality of edge value detectors each responsive to the filtered luminance pixel value for providing an absolute value signal indicative of the presence of a respective edge;

a strong edge detector responsive to each of the edge value detectors for providing a near edge (NE) signal if the absolute value signals are indicative of a distinct near edge image characteristic and providing an edge (E) signal if the absolute value signals are indicative of a distinct edge image characteristic;

a flat region detector responsive to each of the edge value detectors for providing a near flat (NF) signal if the absolute value signals are indicative of a distinct near flat image characteristic and providing a flat (F) signal if the absolute value signals are indicative of a distinct flat image characteristic; and

a texture region generator responsive to the strong edge detector and the flat region detector for providing a texture signal.

4. The apparatus as claimed in claim 3 wherein said plurality of edge value detectors are designated respectively for edges at 0°, 90°, 45° and 135°.

5. The apparatus as claimed in claim 3, wherein said texture region generator comprises a NAND operator for receiving said near-flat signal, said flat signal, said near-edge signal, said edge signal and providing a texture signal.

6. The apparatus as claimed in claim 3 wherein said strong edge detector comprises a preliminary strong edge detection unit receiving the absolute value signal from each of the edge value detectors, the preliminary strong edge detection unit being followed by first and second pixel-based non-linear operation units and a block-based non-linear operation unit, the block-based non-linear operation unit providing the near-edge signal, the second pixel based non-linear operation unit providing the edge signal.

7. The apparatus as claimed in claim 6, wherein said first pixel-based non-linear operation unit is an add only consolidation unit receiving a signal from said preliminary strong edge detection unit and a predetermined threshold and having an output out(i,j) for a given input in(i,j) in accordance with:

$$out(i,j) = \begin{cases} 1 & \text{if } \sum_{(n,m)\in W} in(i-n, j-m) \geq Threshold \\ in(i,j) & \text{otherwise} \end{cases}$$

wherein W is a local window and Threshold is the predetermined threshold.

8. The apparatus as claimed in claim 6, wherein said second pixel-based non-linear operation unit is a remove only consolidation unit receiving a signal from said first pixel-based non-linear operation unit and a predetermined threshold, the remove only consolidation unit having an output out(i,j) for a given input in(i,j) in accordance with:

$$out(i,j) = \begin{cases} 0 & \text{if } \sum_{(n,m)\in W} in(i-n, j-m) \leq Threshold \\ in(i,j) & \text{otherwise} \end{cases}$$

wherein W is a local window and Threshold is the predetermined threshold.

9. The apparatus as claimed in claim 6, wherein said block-based non-linear operation unit receives a signal from the second pixel-based non-linear operation unit and a predetermined threshold signal and provides an output out(i,j) for an input in(i,j) in accordance with:

$$\forall (i,j) \in B,\ out(i,j) = \begin{cases} 1 & \text{if } \sum_{(i,j)\in B} in(i,j) \geq Threshold \\ in(i,j) & \text{otherwise} \end{cases}$$

wherein B is a predetermined block of pixels and Threshold is the predetermined threshold.

10. The apparatus as claimed in claim 9 wherein said said block-based non-linear operation unit further comprises an AND operator for receiving the logical negation of the input signal and the output signal of the block-based add only consolidation and providing the near-edge signal.

11. The apparatus as claimed in claim 3 wherein said flat region detector comprises a preliminary flat region detection unit for receiving the absolute value signals from the edge value detectors; first and second pixel-based non-linear operation units; and an AND operator; wherein the first pixel-based non-linear operation unit receives a signal from the preliminary flat region detection unit, the filtered luminance pixel value, a filtered chrominance component and two threshold values and provides an output signal; wherein the second pixel based non-linear operation unit receives the output signal from the first pixel-based non-linear operation unit, the filtered luminance pixel value, the filtered chrominance component and two threshold values and provides the flat signal; and wherein the AND operator receives the flat signal and the logical negation of the output signal of the first pixel based non-linear operation unit and provides the near-flat signal.

12. The apparatus as claimed in claim 1 wherein the shape-adaptive luminance noise power estimator comprises:

a shape-adaptive windowing local standard deviation estimator responsive to said luminance component for providing a local estimated standard deviation signal;

an additive noise statistical determiner responsive to the local estimated standard deviation signal for generating an additive noise statistical signal; and

a weighting operator responsive to the additive noise statistical signal and region class indicative signal for determining the luminance noise power statistical characteristics indicative signal.

13. The apparatus as claimed in claim 12 wherein the additive noise statistical determiner is further responsive to a coding parameter signal for generating additive noise statistical signal.

14. The apparatus as claimed in claim 13 wherein the additive noise statistical determiner is a look-up table.

15. The apparatus as claimed in claim 12 further comprising a low pass filter responsive to the luminance noise power statistical characteristics indicative signal for smoothing region transitions.

16. The apparatus as claimed in claim 1 wherein the shape-adaptive luminance noise reducer comprises:

a local window segmentation unit responsive to the luminance component Y(i,j) for determining simlar pixels in a window about a considered pixel (i,j) to provide a shape adaptive signal W(i,j);

a similar pixel counter for determining a count N of the number of similar pixels in window W(i,j);

a local mean calculator responsive to the luminance component, window W(i,j) and count N for determining a local mean signal mean[Y(i,j)] of the luminance component;

a local standard deviation calculator responsive to the luminance component, the local mean signal, window W(i,j) and count N for determining a local standard deviation signal of the luminance component;

a MMSE gain calculator responsive to the local standard deviation signal and the luminance noise power statistical characteristics indicative signal for determining a minimum mean square error signal K(i,j); and

a calculation unit for filtering the lumiminace component to determine a filtered luminance signal Y*(i,j) in accordance with the equation:

$$Y^*(i,j) = \mathrm{mean}[Y(i,j)] + K(i,j)[\, Y(i,j) - \mathrm{mean}[Y(i,j)]]. \qquad (19)$$

17. The apparatus as claimed in claim 1, wherein said block-based decoded image signal further includes first and second chrominance components, said apparatus further comprising:

a shape-adaptive chrominance noise power estimator responsive to said chrominance components for estimating statistical characteristics of first and second chrominance pixels associated with said luminance pixel by using local window information associated with each said chrominance pixel to generate a corresponding chrominance noise power statistical characteristics indicative signal; and

a shape-adaptive chrominance noise reducer for filtering each said chrominance component according to said corresponding chrominance noise power statistical characteristics indicative signal.

18. The apparatus as claimed in claim 17 wherein the shape-adaptive chrominance noise power estimator comprises:

a shape-adaptive windowing local standard deviation estimator responsive to said chrominance components and local window information associated with each said chrominance component for providing a local estimated standard deviation signal; and

an additive noise statistical determiner responsive to the local estimated standard deviation signal for generating an additive noise statistical signal for determining the corresponding chrominance noise power statistical characteristics indicative signal.

19. The apparatus as claimed in claim 18 further comprising a multiplier operator responsive to the additive noise statistical signal for generating the corresponding chrominance noise power statistical characteristics indicative signal.

20. The apparatus as claimed in claim 18 wherein the additive noise statistical determiner is further responsive to a coding parameter signal for generating the additive noise statistical characteristics indicative signal.

21. The apparatus as claimed in claim 20 wherein the additive noise statistical determiner is a look-up table.

22. The apparatus as claimed in claim 18 futher comprising:

a chrominance components interpolator responsive to the chrominance components signal for interpolating the chrominace components signal from a first resolution to a resolution of the luminance components signal; and

a chrominance components deinterpolator responsive to the local estimated standard deviation signal for deinterpolating the local estimated standard deviation signal to the first resolution of the chrominace components signal.

23. The apparatus as claimed in claim 17 wherein the shape-adaptive chrominance noise reducer comprises:

a local mean calculator responsive to the chrominance components signal Cu/Cv, a shape-adaptive signal W(i,j) determined from a window of

pixels with similar characteristics to a considered pixel (i,j) of the chrominance components signal and a count N of the similar pixels in W(i,j) for determining a local mean signal mean[Cu/Cv(i,j)] of the chrominance components;

a local standard deviation calculator responsive to the chrominance components signal Cu/Cv, the local mean signal mean[Cu/Cv(i,j)], window W(i,j) and count N for determining a local standard deviation signal of the chrominance component;

a MMSE gain calculator responsive to the local standard deviation signal and the chrominance noise power statistical characteristics indicative signal for determining a minimum mean square error signal K(i,j); and

a calculation unit for filtering the chrominance components signal Cu/Cv to determine a filtered chrominance signal Cu/Cv*(i,j) in accordance with the equation:

Cu/Cv *(i,j) = mean[Cu/Cv (i,j)] + K(i,j)[Cu/Cv(i,j)-mean[Cu/Cv (i,j)]].

24. A method for reducing noise in a block-based decoded image signal including a luminance component, said method comprising the steps of:

analyzing each luminance pixel value of said luminance component according to a corresponding luminance pixel spatial context in a same frame of said image signal to classify the luminance pixel in a selected one of a plurality of predetermined image region classes associated with distinct image region spatial characteristics and to generate a corresponding selected region class indicative signal;

estimating, from said luminance component and said selected region class indicative signal, statistical characteristics of said luminance pixel by using shape-adaptive local window segmentation data associated with the luminance pixel, to generate a corresponding luminance noise power statistical characteristics indicative signal; and

filtering said luminance component according to said luminance noise power statistical characteristics indicative signal.

25. The method of claim 24, wherein said distinct image region spatial characteristics includes edge, near edge, flat, near flat and texture spatial characteristics.

26. The method according to claim 24, wherein said block-based decoded image signal further includes first and second chrominance components, said method further comprising the steps of:

estimating, from said chrominance components, statistical characteristics of first and second chrominance pixels associated with said luminance pixel by using shape-adaptive local window segmentation data associated with each said chrominance pixel to generate a corresponding chrominance noise power statistical characteristics indicative signal; and

filtering each said chrominance components according to said corresponding chrominance noise power statistical characteristics indicative signal.

27. The method as claimed in claim 24, wherein said step of analyzing comprises:

filtering a high frequency noise component of said luminance pixel value and providing a filtered luminance pixel value;

detecting a plurality of edges each responsive to the filtered luminance pixel value and providing a plurality of edge detect signals indicative of the presence of a respective edge;

detecting a strong edge characteristic responsive to each of the edge detect signals for providing a near edge (NE) signal if the plurality edge detect signals are indicative of a distinct near edge image characteristic and providing an edge (E) signal if the edge detect signals are indicative of a distinct edge image characteristic;

detecting a flat region characteristic responsive to each of the edge detect signals for providing a near flat (NF) signal if the edge detect signals are indicative of a distinct near flat (NF) signal if the edge detect signals are indicative of a distinct near flat image characteristic and providing a flat (F) signal if the edge detect signals are indicative of a distinct flat image characteristic; and

detecting a texture region characteristic responsive to the strong edge detecting and the flat region detecting for providing a texture signal.

28. The method as claimed in claim 27 wherein said step of detecting a strong edge characteristic comprises steps of: detecting a preliminary strong edge characteristic in response to the edge detect signals; and evaluating the preliminary strong edge characteristic to provide the near-edge signal and the edge signal.

29. The method as claimed in claim 28, wherein the step of evaluating the preliminary strong edge characteristic comprises comparing a signal indicating the preliminary strong edge characteristic to first and second predetermined thresholds indicating, respectively, a strong edge characteristic and a no edge characteristic and providing an output SE_out(i,j) for a given signal input in(i,j) in accordance with:

$$out(i,j) = \begin{cases} 1 & if \sum\limits_{(n,m)\in W} in(i-n, j-m) \geq Threshold\ 1 \\ 0 & if \sum\limits_{(n,m)\in W} in(i-n, j-m) \leq Threshold\ 2 \\ in(i,j) & otherwise \end{cases}$$

wherein W is a local window about a considered pixel (i,j) and Threshold1 and Threshold2 are the first and second predetermined thresholds respectively.

30. The method as claimed in claim 29, wherein said step of evaluating the preliminary strong edge characteristic comprises comparing the output signal SE_out(i,j) a predetermined threshold indicating a near edge characteristic and providing an output out(i,j) for an input in(i,j) in accordance with:

$$\forall (i,j) \in B,\ NE\_out(i,j) = \begin{cases} 1 & \text{if } \sum_{(i,j)\in B} in(i,j) \geq Threshold \\ in(i,j) & \text{otherwise} \end{cases}$$

wherein B is a predetermined block of pixels about a considered pixel (i,j) and Threshold is the predetermined threshold indicating the near edge characteristic.

31. The method as claimed in claim 30 further comprising the step of determining the near edge signal as the logical AND of the signal NE_out(i,j) and the negated signal SE_out(i,j).

32. The method as claimed in claim 27 wherein said step of detecting a flat region comprises steps of:

detecting a preliminary flat region characteristic in response to the edge detect signals;

determining an output signal in response to the preliminary flat region characteristic, the filtered luminance pixel value, two threshold values and, optionally a filtered chrominance component;

determining the flat signal in response to the output signal, the filtered luminance pixel value, two threshold values and, optionally, the filtered chrominance component; and

determining the near flat signal in response to the flat signal and the logical negation of the output signal.

33. The method as claimed in claim 24 wherein the step of estimating comprises:

determining a local estimated standard deviation signal in response to said luminance component;

generating an additive noise statistical signal in response to the local estimated standard deviation signal; and

applying a weighting operator in response to the additive noise statistical signal and region class indicative signal for determining the luminance noise power statistical characteristics indicative signal.

34. The method as claimed in claim 33 wherein the step of generating the additive noise statistical signal is further responsive to a coding parameter signal.

35. The method as claimed in claim 33 further comprising the step of filtering the luminance noise power statistical characteristics indicative signal for smoothing region transitions.

36. The method as claimed in claim 24 wherein the step of estimating comprises steps of:

determining similar pixels in a window about a considered pixel (i,j) to provide a shape adaptive signal W(i,j) in response to the luminance component Y(i,j);

determining a count N of the number of similar pixels in window W(i,j);

determining a local mean signal mean [Y(i,j)] of the luminance component, in response to the luminance component, window W(i,j) and count N;

determining a local standard deviation signal of the luminance component in response to the luminance component, the local mean signal, window W(i,j) and count N;

determining a minimum mean square error signal K(i,j) in response to the local standard deviation signal and the luminance noise power statistical characteristics indicative signal; and

filtering the lumiminace component to determine a filtered luminance signal Y*(i,j) in accordance with the equation:

$$Y^*(i,j) = mean[Y(i,j)] + K(i,j)[\, Y\,(i,j)-mean[Y(i,j)]].$$

37. The method as claimed in claim 26 wherein the step of estimating from said chrominance components comprises steps of:

determining a local estimated standard deviation signal in response to said chrominance components and local window information associated with each said chrominance component; and

generating an additive noise statistical signal in response to the local estimated standard deviation signal for determining the corresponding chrominance noise power statistical characteristics indicative signal.

38. The method as claimed in claim 37 wherein the step of generating an additive noise statistical signal is further responsive to a coding parameter signal.

39. The method as claimed in claim 37 further comprising steps of:

interpolating the chrominace components signal from a first resolution to a resolution of the luminance components signal; and

deinterpolating the local estimated standard deviation signal to the first resolution of the chrominace components signal.

40. The method as claimed in claim 26 wherein the step of estimating from said chrominance-components comprises steps of :

determining a local mean signal mean [Cu/Cv(i,j)] in response to the chrominance components signal Cu/Cv, a shape-adaptive signal W(i,j)

determined from a window of pixels with similar characteristics to a considered pixel (i,j) of the chrominance components signal and a count N of the similar pixels in W(i,j);

determining a local standard deviation signal of the chrominance component in response to the chrominance components signal Cu/Cv, the local mean signal mean [Cu/Cv(i,j)], window W(i,j) and count N;

determining a minimum mean square error signal K(i,j) in response to the local standard deviation signal and the chrominance noise power statistical characteristics indicative signal; and

filtering the chrominance components signal Cu/Cv to determine a filtered chrominance signal Cu/Cv*(i,j) in accordance with the equation:

$$Cu/Cv^*(i,j) = mean[Cu/Cv(i,j)] + K(i,j)[Cu/Cv(i,j) - mean[Cu/Cv(i,j)]].$$